
उच्च दाब बॉयलरों के लिए जल के उपचार के
लिए अभ्यास संहिता
(दूसरा पुनरीक्षण)

Code of Practice for Treatment of
Water for High Pressure Boilers
(Second Revision)

ICS 13.060.25

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FOREWORD

This Indian Standard (Second Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Water Quality for Industrial Purposes Sectional Committee had been approved by the Chemical Division Council.

The terms low, medium, and high, used with pressure in boiler practice, are not definite but relative. However, it is customary to call those boilers which operate at pressures below 2.0 MN/m^2 (20 kg/cm^2) as low-pressure boilers; those working between 2.0 MN/m^2 and 5.9 MN/m^2 (20 kg/cm^2 and 60 kg/cm^2) as medium pressure boilers; and those operating at pressures above 5.9 MN/m^2 (60 kg/cm^2) as high-pressure boilers.

The treatment of water for low pressure boilers, is given in IS 1680, which, though mainly prepared for the guidance of operation of low-pressure boilers, is also applied to the operation of medium pressure boilers with the conditions given for them where necessary. The procedures laid down in this code are for general guidance of high-pressure boilers only and each case has to be treated on its own merit, taking into consideration the plant cycle, equipment design and plant and process requirements. High pressure boilers are not riveted, they are welded and stress relieved. This fact has been one of the guiding considerations in formulating this code.

This standard was first published in 1967, which was covering boilers operating at pressures above 4.1 MN/m^2 (42 kg/cm^2).

In the first revision of this standard published in 1983 the following modifications were incorporated:

- a) Standard was made applicable to boilers operating at pressures above 5.9 MN/m^2 (60 kg/cm^2);
- b) Condensate purification was incorporated;
- c) Control of concentration of solids in boiler water was incorporated;
- d) Protection of idle boilers was incorporated; and
- e) Care of high-pressure drum-type boilers during condenser tube leakage was incorporated.

In this second revision the following modification have been incorporated:

- a) Feedwater treatment methods have been incorporated;
- b) Boiler water treatment methods have been incorporated;
- c) Wet and dry method for storage have been updated;
- d) References, ICS No. have been updated; and
- e) Other editorial changes have been done to bring the standard in the latest style and format of Indian Standards.

The composition of committee responsible for the formulation of this standard is listed in Annex A.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 2022 'Rules for rounding off numerical values (*second revision*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard
**CODE OF PRACTICE FOR TREATMENT OF WATER FOR HIGH
 PRESSURE BOILERS**
 (*Second Revision*)

1 SCOPE

This code deals with the chemical methods of attaining the conditions to be aimed at, in the water side of boilers operating at pressures above 5.9 MN/m² (60 kg/cm²) at the drum and for once-through type boilers.

2 REFERENCES

The standards listed below contain provisions which through reference in this text, which constitute provisions of this standard. At the time of publications, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards listed below:

IS No.	Title
IS 3025 (Part 39) : 2021	Methods of sampling and test physical and chemical for water and wastewater: Part 39 Oil and grease (<i>second revision</i>)
IS 10496 : 1983	Specification boiler water for feedwater, and condensate for pressure boilers

3 OBJECTIVES OF TREATMENT

The objective of chemical treatment is to prevent corrosion of the boiler and fittings, scale and deposit formation on heat transfer surfaces, reducing corrodent concentrations and maintaining high level of steam purity to avoid deposition on turbines. For this purpose, the composition of feedwater, boiler water and condensate are maintained as given in IS 10496. In most cases, the return condensate is the bulk of feedwater and the make-up is obtained from evaporated water or demineralized water.

4 TREATMENTS

4.1 The makeup water is obtained from the following sources:

- a) *Condensate or Evaporated Water*

Care shall be taken that it is free from oil. If any oil is present, it shall be removed with the help of special oil-removal plants. The water shall be sufficiently alkaline, pH being above 8.5. If necessary, an alkali is added to obtain this condition. The silica level shall not exceed 20 ppb as SiO₂. If the make-up is obtained from evaporated water, and if it is softened by the lime-soda process before evaporation, addition of magnesium hydroxide or magnesium oxide along with softening chemicals would remove silica.

- b) *Demineralized or Deionized Water*, with silica removal.

4.2 Feedwater Treatments

4.2.1 The three recommended feedwater treatments are as follows:

- a) *All Volatile Treatment (Reducing) AVT (R)*

Reducing agent such as hydrazine hydrate is added at Condensate Extraction Pump (CEP) discharge. The pH is maintained by using ammonia. This feedwater treatment is generally suggested for mixed metallurgy systems.

- b) *All Volatile Treatment (Oxidized) AVT (O)*

No reducing agent is added. Ammonia is added for pH control. This feedwater treatment is suggested for all-ferrous systems, especially in those units that generally have good feedwater purity (ACC < 0.2 µS/cm).

- c) *Oxygenated Treatment (OT)*

Ammonia plus oxygen is added. This feedwater treatment is suggested for all-ferrous systems with the ability to maintain feed water cation conductivity of less than 0.15 µS/cm.

4.3 Boiler Water Treatments

4.3.1 There are four recommended boiler water treatments:

a) All Volatile Treatment (AVT)

In this the feed water treatment is either AVT(R) or AVT(O) as appropriate and no further chemical treatment is applied within the boiler.

b) Phosphate Treatment (PT)

In this treatment a drum boiler is dosed with tri sodium phosphate (TSP). Dosing of the boiler water with sodium hydroxide up to 1 ppm is also allowed as a supplement to TSP (during condenser tube leakage) when needed for pH control but addition of sodium hydroxide is generally not recommended for drum pressures above 170 kg/cm².

c) Caustic Treatment (CT)

In this treatment a drum boiler is dosed with

sodium hydroxide only incase when OEM is recommended. This treatment is generally not recommended for drum pressures above 170 kg/cm².

d) Oxygenated Treatment (OT)

In this treatment the feed water dosed with oxygen as needed for OT is used in the boiler without further treatment. OT may be used in cycles with once-through or drum type boilers, however, with the latter feed water oxygen dosing must be more carefully controlled so as to avoid possible corrosion in the boiler.

The water chemistry of with boiler drum and drumless boiler is given at Fig. 1.

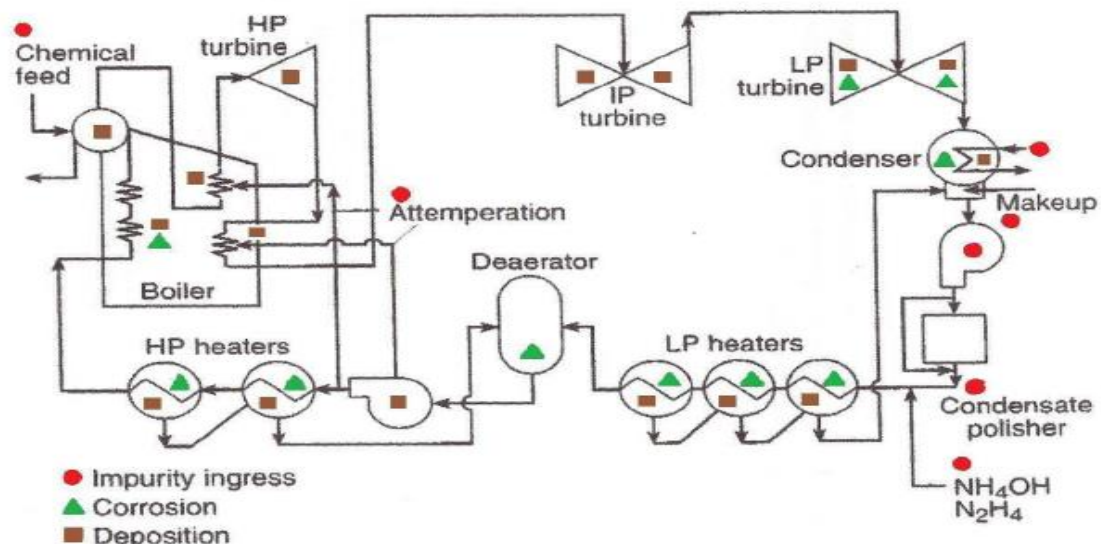
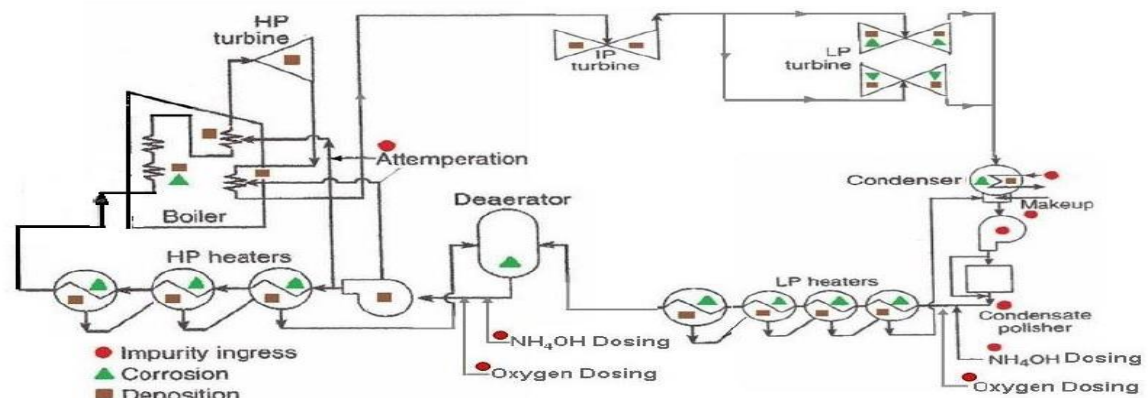
WITH BOILER DRUM**DRUMLESS BOILERS (SUPERCRITICAL UNITS)**

FIG. 1 CYCLE CHEMISTRY

4.4 Condensate Purification

4.4.1 Condensate purification is a means of recovering contaminated condensate for re-use as feed water. Otherwise, it may have to be discarded and replaced by treated make-up water at extra expense. The principal sources of contamination are as follows:

- a) During commissioning and early operation of a boiler plant the condensate is usually contaminated with, mill scale and other debris which increases the risk of corrosion of the tubes in a water-tube boiler. In a once-through boiler they may lead to abnormal pressure drops and unacceptable contamination of the steam. Silica can also be particularly troublesome during the period and the commissioning may be delayed by excessive demands for water brought about by the large amount of blowdown required to limit the levels of silica in boiler water and steam;
- b) Condensate is often contaminated for a period of several hours after start-up following an overnight or weekend shutdown and it may be necessary to reject such condensate from the system with a consequent increase in demand on the water supply;
- c) Some contamination of condensate by products of corrosion of the materials of construction occurs during normal operation and, even if other contamination is absent, purification plant may be necessary to meet the highest standards for chemical quality of feed water; and
- d) Where steam is used for industrial process heating and is recovered as condensate, it may be contaminated by untreated water or by chemicals used in the industrial process. Precautions should be taken to prevent these contaminated condensates being returned to the boiler without treatment. Wherever possible, such contamination of condensate should be prevented at source.

4.4.1.1 The decision to install condensate purification plant and the capacity and type of equipment depend upon the design, duty and feed water specifications of the individual boiler plant, and comparative costs.

4.4.1.2 When the condensate contains more than a trace of impurity it may be more economical to return it up-stream of the make-up water treatment

plant rather than to install a separate plant to purify the condensate if the ionic load permits.

4.4.1.3 If economic consideration favor partial rejection of the condensate, an automatic instrument should be used to monitor the contamination and operate the rejection or recovery devices in accordance with the varying quality of the condensate.

4.4.2 Condensate Polishing

A plant is often provided for purification of slightly contaminated condensate that forms the major part of the feed to high pressure boilers. Such removal of traces of impurities, usually iron and copper, is referred to as 'condensate polishing'. This provision is of particular importance with 500 MW and above MW units and once-through boilers and where condensate is recovered from industrial processes or heating.

4.4.2.1 Mixed bed ion-exchange, preferably externally regenerated to avoid contamination by regenerants, is an essential part of condensate polishing. It may be preceded by integral or separate cation exchange, with or without a filtration stage. Several types of filters have been used successfully, including precoat filters, paper cartridge filters and fibre-wound candles. Magnetic separators have also been used.

4.4.2.2 The purpose of the filter is to reduce the quantity of suspended solids reaching the ion-exchange units and hence lower the risk of fouling the resins. The integral or separate cation exchange unit also protects the mixed bed resins by removing a proportion of the suspended solids and, by reducing the cationic load to the mixed beds, helps to ensure that the highest quality of purified condensate is obtained. The cation resin may be used either in the hydrogen or in the ammonia form; the former gives greater purity, but the latter may be cheaper to operate in some cases.

4.4.2.3 Two other system have also been successfully adopted; mixed beds alone and filters precoat with expendable powdered or micro-bead resins, installed either alone or as a component of the condensate polishing plant.

4.4.3 Condensate Contamination by Cooling Water

Entry of cooling water into the steam and condensate system is a common cause of contamination of condensate. The cooling water may be fresh, brackish or sea water from once-through cooling systems or treated water from a circulating evaporative cooling system in which

dissolved solids have concentrated.

4.4.3.1 Condensates contaminated in this manner may usually be purified by treatment in a plant similar to that used for treatment of makeup water or, if the proportion of condensate is small, by adding the condensate to the raw water going to the make-up water treatment plant.

4.4.4 Condensate Contamination by Oil

Every effort should be made to avoid contamination of feed water by oil, if necessary, by rejecting oily condensate.

4.4.4.1 Vegetable oils introduced into alkaline boiler water are usually converted into soaps that can rapidly form a stable foam on the surface of the boiler water and may lead to severe contamination of the steam. Where this risk exists, continuous addition of an antifoam is prudent even when contamination is not apparent.

4.4.4.2 Mineral oil introduced to the boiler may form non-wettable films on heat transfer surfaces and interfere with the detachment of steam bubbles leading to inadequate cooling by the boiler water. Therefore, severe corrosion or failure of such surfaces may occur.

4.4.4.3 If sludge in a boiler absorbs oil, it may become less mobile and obstruct circulation. Similar obstruction may occur in condensate lines and steam traps owing to the presence of oil, which is carried forward with the steam.

4.4.4.4 Various treatment processes are available for substantially removing small amounts of oil in condensate. Some of these processes are as follows:

- a) Coagulation, flocculation, and sedimentation in alkaline conditions in a sludge-blanket clarification plant followed by filtration through an anthracite filter. It is capable of handling the greatest variations in oil contamination.
- b) Conventional coagulation, and flocculation in alkaline conditions in a sedimentation plant, followed by filtration through an anthracite filter.
- c) Absorption of the oil by a pre-coat of aluminum hydroxide or ferric hydroxide upon a filter bed of anthracite or sand is capable of handling large flow rates at low levels of contamination.

d) Absorption onto an expendable fixed bed of activated carbon, substantially removes low levels 1 mg/l to 2 mg/l of oil.

e) Filtration and absorption by a pre-coat of diatomaceous earth upon a filter candle is suitable for small flow rates and low levels, for example, 5 mg/l, of oil contamination.

4.4.4.5 The choice of treatment depends upon the amount of contamination, the type of oil and the amount and temperature of the condensate to be treated. It is difficult to measure accurately small concentrations of oil in water. It is recommended that treatment to remove oil should reduce it to a level; that is not detectable by the method described in IS 3025 (Part 39).

4.4.4.6 Each case needs individual consideration; but as a general guide method that use diatomaceous earth or sand filtration may not be suitable, if a feed water of low silica content is required; and an anthracite filter bed should be used; methods based on continuous coagulation may be unsuitable where feed water of low dissolved solids content is required, unless the purified condensate is subsequently treated in a demineralizing plant.

The water obtained in **4.1** is mechanically de-aerated to remove air and dissolved gases. For water to be used for boilers operating above 5.9. MN/m² (60 kg/cm²), a high degree of removal of oxygen should be attained; dissolved oxygen should preferably be less than 0.010 mg/l in the feed.

4.5 The de-aerated and degassed water is conditioned as given in **4.5.1** to **4.5.3**.

4.5.1 For the removal of traces of oxygen dissolved in the water, a suitable amine is used. Sodium sulphite, which is used in low and medium pressure boilers is unsuitable for use in high pressure boilers as it decomposes at high temperatures to produce sulphur dioxide or sodium sulphide or both, which are corrosive. The amine used generally is hydrazine. It reacts with oxygen from the water to form nitrogen and water. Thus, neither the total solids are increased, nor any corrosive substances produced in the boiler.

4.5.1.1 At higher temperatures in the boiler, hydrazine decomposes into ammonia and nitrogen. Ammonia and hydrazine being volatile, a portion of these two substances returns to the condensate. This makes the condensate alkaline and protects the condenser line from corrosion.

4.5.2 Phosphate is added to the boiler water in the drum for maintaining *pH* and also to ensure the removal of any hardness-causing salts that might have accidentally found access to the feed water.

4.5.3 A certain amount of alkali is added to maintain the desired alkalinity in the boiler feed water. The alkali to be used may be amines or ammonia. A volatile amine such as cyclohexylamine or morpholine may also be added. Amines make the condensate alkaline.

5 CONTROL OF TREATMENT

5.1 Control of treatment is effected by examining feed water, boiler water, steam and condensate. Feed water is examined for hardness, dissolved oxygen, silica, hydrazine, *pH*, iron, copper, oil, specific conductivity, After Cation Conductivity (ACC), sodium, ORP and oxygen consumed in 4 hr. Boiler water is examined for *pH*, hardness, caustic alkalinity, dissolved solids, specific conductivity, ACC, silica, phosphates, chlorides, and hydrazine. Condensate should be tested for *pH*, hardness, oil, ACC, silica, ammonia, sodium, dissolved oxygen and iron and copper, and demineralized water should also be tested for *pH*, silica and hardness from time to time.

5.2 In some modern high pressure boiler plants, instruments are fitted in the condensate line, feed system and steam lines which indicate and record conductivity, *pH* value and dissolved oxygen in the feed water; conductivity, and dissolved oxygen in condensate; and conductivity, and sodium in steam. These are often provided with warning alarms set at desired values. These aids are valuable in the operation of the boiler plant.

5.3 Control of Concentration of Solids in Boiler Water

5.3.1 When a water containing dissolved impurities is boiled and the vapor (steam) is driven off, most of the salts remain and concentrate in the diminishing bulk of water, thus the dissolved solids content increases. If the evaporation is continued some of the impurities come out of solution as scale or as suspended solids. These particular impurities will cease to concentrate as dissolved solids, but the suspended solids so formed concentrate.

5.3.1.1 In boiler design it is difficult to prevent the entrainment of small amounts of boiler water with the steam though this can be greatly limited. This entrainment normally increases with continuing concentration of dissolved and suspended solids and alkalinity. In order to limit the amount of solids in the steam it is necessary to control the

concentrations of dissolved and suspended solids in the boiler water. At pressures greater than 3.9 MN/m^2 (40 kg/cm^2) some solids have a significant solubility in steam.

5.3.1.2 In practice one or several impurities in the boiler feed water may be critical with respect to their concentration in the boiler water. The following are examples:

- a) The level of dissolved solids should be restricted to maintain steam purity;
- b) The silica content may have to be restricted to limit the level of silica in the steam or the formation of silica scales in the boiler;
- c) In high pressure boilers the level of chloride ion should be limited to minimize corrosion;
- d) The level of alkalinity should be limited to maintain steam purity and minimize caustic attack; and
- e) The level of suspended solids should be restricted to below that at which adherent deposits form, or steam purity or circulation are impaired.

5.3.1.3 The limits for these and other critical constituents are given in IS 10496. In certain special cases of design or operation limitations may have to be imposed that are not covered by that standard. It is then normal for a boiler manufacturer to recommend values for the maximum concentration. In general, these limits may be set from experience or determined by trial. Once set they should be scrupulously observed.

5.3.2 Blowdown

Blowdown may be continuous or intermittent, or a combination of both. It may be manually or automatically controlled.

5.3.2.1 Continuous blowdown

Continuous blowdown is a continuous removal of boiler water controlled by a specially designed adjustable valve or by an orifice plate. The installation of heat recovery equipment may be economically justified. Suspended solids may block or erode the adjustable valve or orifice plate and continuous blowdown is, therefore, usually limited to the control of dissolved solids. Additional manual blowdown is necessary to control suspended solids and prevent the build-up of sludge.

5.3.2.2 Intermittent blowdown

Intermittent blowdown may be affected by specially designed valves either operated by hand or automatically controlled, for example, by timers, feed water flow or conductivity. Where automatic valves are installed the manual blowdown valve shall be operated at intervals to ensure that the latter is clear. It should be noted that the most effective and economic use of all types of intermittent blowdown valves is achieved by frequent full-open operation for short periods rather than extended use at infrequent intervals. It is usually not practicable to recover waste heat from infrequent intermittent blowdown.

6 PROTECTION OF IDLE BOILERS

6.1 Neglect of boilers during standing periods frequently, leads to serious corrosion in the steam and water spaces from which further attack may develop during subsequent working periods. Various methods of corrosion protection may be applied although the choice of method usually depends upon the length of time for which the boiler is to be stored. Procedures for the protection of the fireside of an idle boiler are outside the scope of this standard.

6.2 Storage Overnight

It is usually sufficient to allow the boiler to stand-by with the water conditions recommended for normal steaming provided these are maintained during the idle period. Any feed water that is added subsequently should have been adequately de-aerated. The space above the water should preferably be kept filled with steam or nitrogen at a pressure greater than atmospheric. Special precautions may have to be taken to protect superheaters and expert advice should be sought.

6.3 Storage for Extended Periods

6.3.1 Wet Method

If the boiler is likely to be out of service for more than a few days, but may be needed for steaming at short notice, it should be completely filled with correctly conditioned water. Non-drainable superheaters should be filled only with condensate quality water treated with volatile chemicals such as hydrazine or ammonia. It is most important that, pockets of air are not allowed to remain in the boiler and there should be no leakage.

For optimum storage of the boiler, increase blow down on shutdown to achieve minimum concentrations of contaminants (like phosphate, chloride, silica etc) in the boiler water.

6.3.1.1 Shutdown duration < 4 days

6.3.1.1.1 After shut down of unit, keep boiler above saturation temperature and pressurized as long as possible.

6.3.1.1.2 The nitrogen should be applied while the superheater/drum is still at positive pressure (for example, $\sim 2 \text{ kg/cm}^2$). As the steam pressure decays, nitrogen fills the steam space. Maintain 0.3 kg/cm^2 to 0.5 kg/cm^2 nitrogen cap.

6.3.1.2 Shutdown duration > 4 days

6.3.1.2.1 For Once-through boiler, super heater can be filled by overflowing of separator (separator water turbidity < 1 NTU) after complete mixing of ammonia solution in boiler. Filling water quality is specified in Table 1. Boiler and Super heater vents samples pH should be 10 to 10.5.

Table 1 Feed (filling) Water Quality for Wet Storage
(Clause 6.3.1.2.1, 6.3.1.2.5, and 6.3.1.2.6)

Sl No.	Shutdown Duration	All Ferrous System FW Regime: AVT(O)/OT	Mixed Metallurgy System FW Regime: AVT (R)
(1)	(2)	(3)	(4)
i)	< 4 days	Maintain the same chemistry parameters as that of normal pressure	
ii)	> 4 days	pH 10.0 to 10.5	For equipments containing copper alloy (Condenser, feed water, heaters etc) pH: 9.0 to 9.2 Hydrazine: 40 ppm to 50 ppm Dissolved oxygen (DO) < 100 ppb *(preferably) Filling water turbidity should be less than 1 NTU
			For equipments containing only ferrous metallurgy (Boiler, Superheater, etc) pH: 9.5 to 10.0 Hydrazine: 200 ppm to 250 ppm

* To avoid pitting corrosion, low DO water/deaerated water should be used for filling and pressurization of the system.

6.3.1.2.2 For drum type units, super heater should be filled only by backfilling line and not be filled by flooding the boiler drum into the superheater. If boiler uses any type of solid alkali treatment (phosphate or caustic) during its normal operation, filling the super heater by overflowing the boiler will cause contamination of the superheater and turbine during subsequent operation. After completion of superheater filling, start filling of boiler with water of quality as specified in Table 1.

6.3.1.2.3 Care must be taken not to exceed permissible DT between boiler metal temperature/superheater metal temperature and feed water temperature as prescribed by OEM recommendations.

6.3.1.2.4 Establish and maintain 0.3 kg/cm^2 to 0.5 kg/cm^2 nitrogen cap at the vents of super heater, steam drum/separator and other preserved system after completion of filling.

6.3.1.2.5 If N_2 capping facility is not available, then keep boiler always pressurized up to 10 kg/cm^2 . Feed water quality (using for pressurization) shall be as specified in Table 1.

6.3.1.2.6 During wet preservation, chemical concentration near surface can be lowered and to avoid pitting corrosion, it is recommended to circulate the boiler once in a week by boiler circulating pump (if provided). If chemical concentration is found lower than specified values (see Table 1), the chemical mixed water to be injected in the preserved water to restore the desired chemistry parameters. After taking any fresh makeup in boiler, it should be thoroughly circulated by boiler circulation pump (BCP) and chemistry parameters checking to be done. For units, where boiler circulation pump is not in design, the boiler water circulation can be maintained via a suitable capacity external pump arrangement. An alternate method is to drain some reasonable amount of water from boiler and refill with fresh treated water of quality as specified in Table 1 on a regular interval (preferably fortnightly). However, circulation of boiler water by external pump will be a good option. Boiler water chemistry parameters and quantity of makeup water is to be recorded in preservation protocol.

6.3.1.2.7 Only an equipment requiring maintenance needs to be drained and nitrogen (if used for capping) purged with air to provide an environment suitable for safe entry of personnel.

6.3.1.2.8 If boiler is drained for any reason, then boiler shall be refilled with deaerated treated water of quality as specified in Table 1 and cap with nitrogen or pressurized.

NOTES

1 High chemical laden boiler water should be drained prior to boiler startup.

2 Hydrazine should not be used for startup and layup on AVT (O)/OT units.

6.3.2 Dry Method

When a boiler is not likely to be required for a long period, it is advisable to empty it completely and dry it thoroughly. Particular attention should be paid to any parts that are not self-draining. Where possible the boiler should be blown through with a stream of warm air to make sure that all surfaces are completely dry. Any deposits should be removed, since they tend to retain moisture. To avoid the ingress of moisture into the boiler it is advisable to remove and blank-off all connections.

Dry lay-up with instrument air is not to be done at sea-shore stations.

6.3.2.1 Procedure

6.3.2.1.1 The main steam temperature is decreased at a rate of $50 \text{ }^\circ\text{C/h}$ to $60 \text{ }^\circ\text{C/h}$ after boiler shutdown.

6.3.2.1.2 When main steam pressure reached 10 kg/cm^2 in pendant type SH (non-drainable SH) and 5 kg/cm^2 in horizontal type SH, open all vents valves and eject the steam in tubes and pipes. Drum/separator vents to be opened at 2 kg/cm^2 .

6.3.2.1.3 When water wall temperature becomes $110 \text{ }^\circ\text{C}$, open the water wall section drain valves (latent heat of WW will be used to dry WW) and then drain all the water in the water wall section. If thermocouple is not there it should be mounted on water wall firing floor near corner.

6.3.2.1.4 Complete box up of boiler to be ensured after stoppage of fans (APH FG inlet temperature $< 220 \text{ }^\circ\text{C}$) and seal trough sealing to be maintained. All manhole and peephole to be kept closed to ensure drying of the boiler heating surfaces by the latent heat of component itself.

6.3.2.1.5 After completion of draining, start instrument air purging when minimum acromat temperature reaches approx. $110 \text{ }^\circ\text{C}$ or if acromat not available SAPH flue gas I/L temperature reaches $110 \text{ }^\circ\text{C}$ or steam stops coming out of vent line. Instrument air at ambient temperature can be filled for dry preservation. Arrangements are to be made for Instrument air-line to be routed through pent-house to give hot air. This is preferable but not necessary to start with.

6.3.2.1.6 Pressurize the boiler internal and other circuits with instrument air and maintain pressure in

a range of 0.3 kg/cm² to 0.5 kg/cm² (just above the atmospheric pressure). Maintain partial opening of header drains and vents at opposite end (if drain on LHS is opened then vent of RHS to be used for filling to avoid air short circulation), at least one drain and one filling line in all circuits, to establish flow of instrument air and also to control the boiler internal air pressure.

6.3.2.1.7 After injecting instrument air, measure the relative humidity at the lowest drain points of each circuit and maintain RH < 35 percent to avoid any dew formation in preserved equipment/circuits.

6.3.2.1.8 Measure and record dew point of purge-in air, relative humidity of purge out air and air pressure of system on daily basis. Measuring location for the relative humidity:

Furnace front wall inlet header drain line/low point drain for both drum type and once-through boilers;

- a) Economizer inlet drain or any other suitable location;
- b) Hot reheat line drain valve left and right side; and
- c) Any other suitable location based on local conditions.

6.3.2.1.9 Inner most loop of platen SH/final SH to be checked for any condensation by radiography/coil heating and in case of any water in the loop, instead of dry only wet preservation to be employed. However, reheater preservation will remain dry preservation in all situations. If reheaters bottom bends are dry, then dry preservation by instrument air if not then by N₂ gas (reheater vents to be opened 30 min before killing vacuum).

6.3.2.1.10 Dry preservation procedure in pendant type boiler to be kept under observation.

NOTE — Dry lay-up involves rapid draining of water-touched components and evacuation of reheat steam lines (using the vacuum in condenser) while the piping is still hot, followed by continuous purging with instrument air (Relative Humidity of purge-out air should be < 35 percent)/dehumidified air or nitrogen gas to maintain a low moisture environment throughout the system.

7 CARE OF HIGH-PRESSURE BOILERS DURING CONDENSER TUBE LEAKAGE

7.1 Boiler water regime requires careful monitoring control and adjustment whenever condenser tube leakage is suspected or confirmed. The condenser

tube leakage brings large amount of chlorides into the condensate and consequently into the feed water. This is more predominant in sea water cooled power stations where magnesium chloride and other forms of chlorides can leak in large quantities. These are hardness salts and acid forming in nature due to hydrolysis reaction at high temperature. Whenever the feed water gets contaminated by the cooling water leakage from the condenser the following changes take place in the boiler water in the drum:

- a) pH of, boiler water drops rapidly due to the acid forming nature of condenser leakage salts;
- b) The phosphate level of boiler water drops down very low. This is due to consumption of the residual phosphate by its reaction with hardness in leakage salts to form sludge constituents; and
- c) Specific Conductivity, chloride and silica of boiler water rises due to increasing salt concentration brought about by condenser leak.
 - Online Specific conductivity of hotwell (L/R)-both passes or only one pass-shows increasing trend.
 - Feed water ACC (online) shows increasing trend.
 - Increasing trend of condensate online ACC/DCC and sodium from recommended values.

In case of increasing trend of the above online parameters, offline testing of condensate and feed water silica; boiler drum silica and chloride; and hardness in condensate, feed and boiler samples are to be done on hourly basis to further ascertain the trend.

7.2 Under these circumstances experience indicates accelerated corrosion of boiler tubes and consequent tube failures can be caused even if such operation is limited only to a few hours. In such a situation, the following course of action is recommended. It should be realized that operation of the boiler with a condenser leak requires extreme care and judgement. Failure to follow instructions as mentioned below would lead to tube failure at a later stage:

7.2.1 Immediately start chemical injection pumps to maintain excess phosphate and pH conditions in boiler water as specified in Table 2.

Table 2 Phosphate and pH Conditions in Boiler Water Depending on the Boiler Pressure
(Clause 7.2.1)

Sl No.	Characteristic	Limits Recommended	
		For Boiler Pressure for Boiler Pressure 6.0 MN/m ² to 9.8 MN/m ² (in the drum)	For Boiler Pressure for Boiler Pressure 9.9 MN/m ² (in the drum) and Above
(1)	(2)	(3)	(4)
i)	Phosphates (as PO ₄), mg/	5 to 40	5 to 20
ii)	l pH value	9.1 to 10.4	9.1 to 10.1

7.2.1.1 The phosphate and pH measurements in boiler water should be made every 30 min and the phosphate pump should be operated based on the measurements to maintain the above regime. This would require, depending on the severity of tube leakage, extra dosage of phosphate. This can be done either by increased running of the phosphate pump at the maximum capacity or by increasing the strength of the phosphate solution charged to the tank.

7.2.1.2 Solid alkali dosing is to be continued for maintaining boiler drum pH within recommended limits.

7.2.1.3 Some operators rely on dosing caustic soda (NaOH) in boiler drum under such conditions to restore quickly the boiler water pH. Caustic soda dosing should be done with utmost care, as concentration of free hydroxide may lead to corrosion of boiler tubes. In such cases caustic and phosphate (preferably disodium phosphate) shall be combinedly dozed together, and the pH and phosphate content shall be closely monitored such that pH for the corresponding phosphate residual does not fall above the curve (Fig. 2). The region above the curve indicates the presence of free hydroxide.

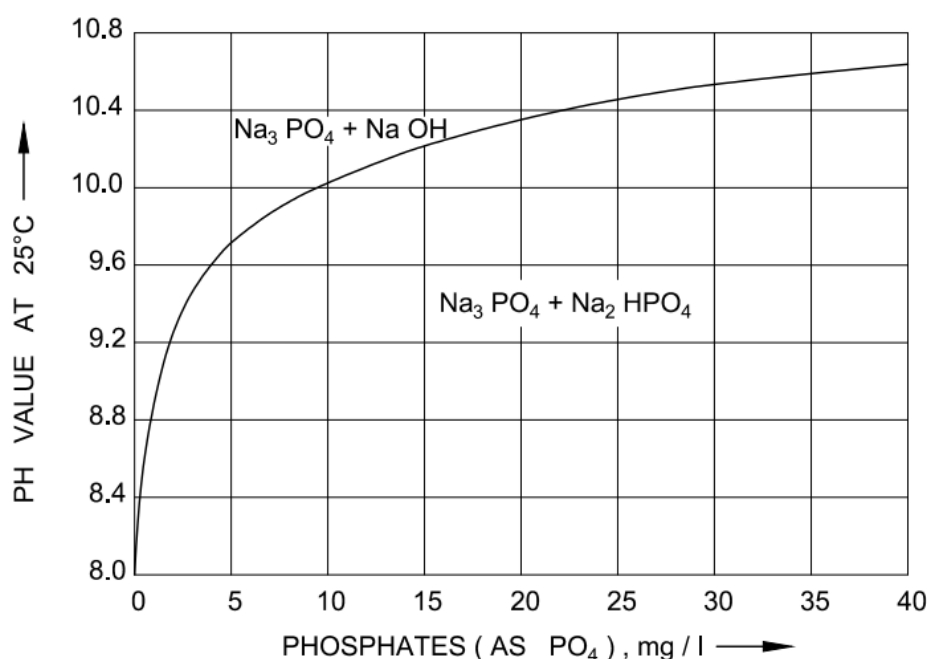


FIG. 2 RECOMMENDED COORDINATED PHOSPHATE CURVE

NOTE — Operation above the curve, which results in free hydroxide, is to be avoided.

7.2.2 Increase blow down to the extent possible to keep the conductivity in boiler within the limits as specified in Table 3.

Table 3 Limits of Conductivity in the Boiler
(Clause 7.2.2)

Sl No.	Boiler Pressure (in the drum), MN/m ²	Specific Electrical Conductivity at 25 °C, µS/cm
(1)	(2)	(3)
i)	6.0 to 9.8	400
ii)	9.9 to 11.8	200
iii)	11.9 and above	100

7.2.3 Monitor the following at an interval of every 30 min.

- Condensate sample either from ejector or from hot well for conductivity; and
- Boiler water sample for pH, phosphate, and conductivity.

7.2.4 Isolate the condenser section one by one for locating the damaged section and isolate and repair the damaged section. (If damaged condenser section cannot be isolated and repaired, shut down the unit.)

7.2.5 Do not continue to operate the unit if pH of boiler water cannot be maintained above 8.0 or the conductivity as given 7.2.2.

7.2.6 Avoid unnecessary use of desuperheater spray by permitting reheat temperature to fall or by reducing load.

7.2.7 If the unit is shut down-for condenser repair, drain and flush the system to the extent possible and

establish wet lay-up of boiler unit and auxiliary equipment during condenser repair.

7.2.8 Wherever CPU is available in drum-type units, both CPUs are to be kept in service for purification of contaminated hotwell water.

7.2.9 For drum less boiler units, 100 percent condensate should pass through CPU and in case condensate water quality at CPU outlet deviate from normal limits and parameters cannot be controlled, unit should be shut down.

7.2.10 For units operating on OT, stop injecting oxygen into the feed water if feed water after cation conductivity (ACC) exceeds 0.20 µS/cm, convert the boiler feed water treatment to AVT (O) and adequate ammonia is dosed to maintain system pH between 9.3 to 9.4.

7.2.11 Under any circumstances the leaking pass should be isolated before Cation conductivity in CEP sample reaches 1 µS/cm for all ferrous sub critical (1.2 µS/cm for mixed metallurgy) and 0.6 µS/cm for supercritical units. In case of Supercritical units with series condenser if isolation is not possible then prepare for shutdown.

7.2.12 For drum type units, when feed water Cation conductivity of sample shows increasing trend and reaches to 1.0 µS/cm or Boiler water pH (measured at 25 °C) falls to 8.0 with further descending trend, unit should be taken under shut down immediately. Units under exclusive AVT (R) operation with no phosphate dosing to be taken under shutdown if ACC > 1.5 or pH < 7.0.

7.2.13 In case of supercritical units and sub critical drum-less units with AVT (O) operation, when economizer inlet ACC is > 1.0 µS/cm, or sodium > 20 ppb or pH drops to 7.0, the unit should be taken into shut down immediately.

ANNEX A
(Foreword)

COMMITTEE COMPOSITION

Water Quality for Industrial Purpose Sectional Committee, CHD 13

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Bhabha Atomic Research Centre, Mumbai	SHRI K. P. BHATTACHARYYA (Chairperson)
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Bharat Heavy Electrical Limited, Thiruchirapali	SHRI SHAILENDRA KUMAR K. ANANDA BABU (<i>Alternate</i>)
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Ion Exchange India Limited, Mumbai	SHRI SACHIN SAHA DR RENU SARAPH (<i>Alternate I</i>) SHRI ANIL K. KHERA (<i>Alternate II</i>)

<i>Organization</i>	<i>Representative(s)</i>
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